

**Most of the universe is *dark*!**

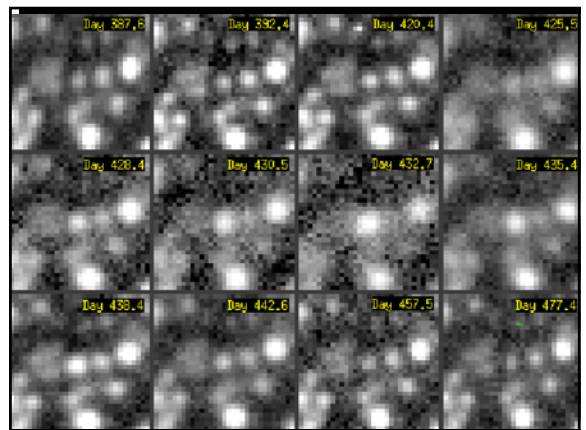
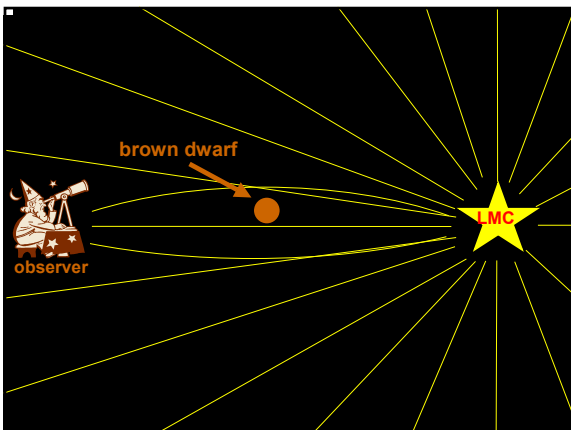
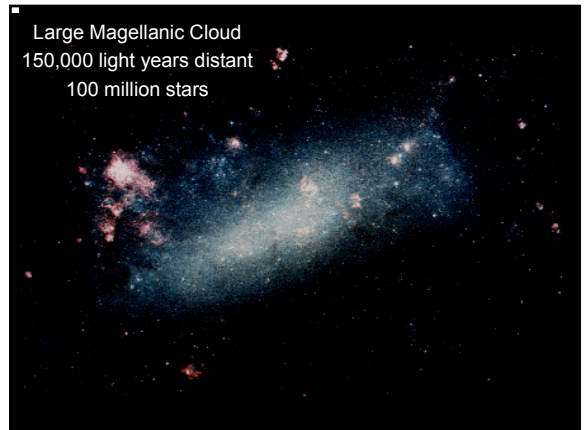
- Modified Newtonian dynamics
- Planets
- Mass disadvantaged stars
  - brown
  - red
  - white
- Black holes

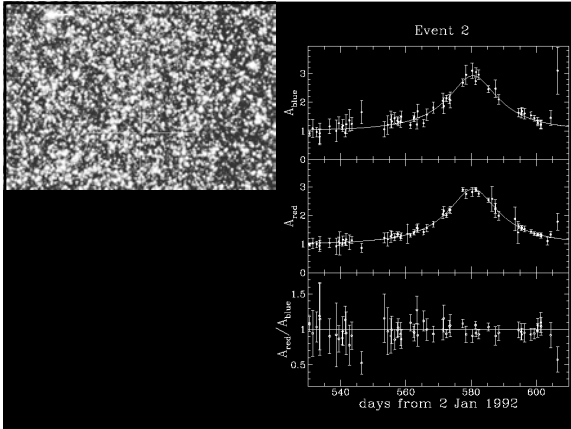
gravitational  
microlensing

**Velocity = Mass  
x Acceleration**

The time has come to  
great celebration and  
accomplishment at the  
bottom of this mountain.  
Thousands of spectators  
have been sent to the edge.  
Each moment waits to  
proceed and conclude, all  
the power there is in the  
direction forward.

*Madhvi-Khanna*

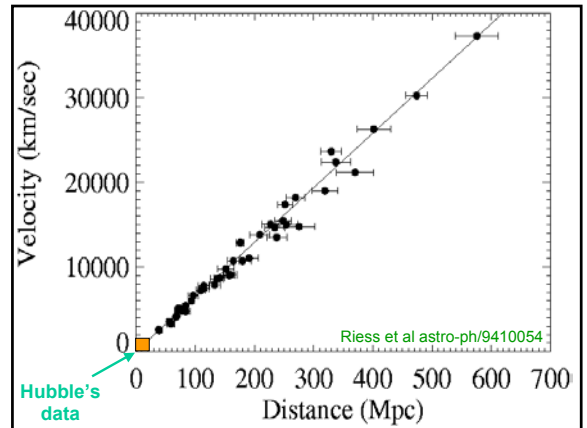
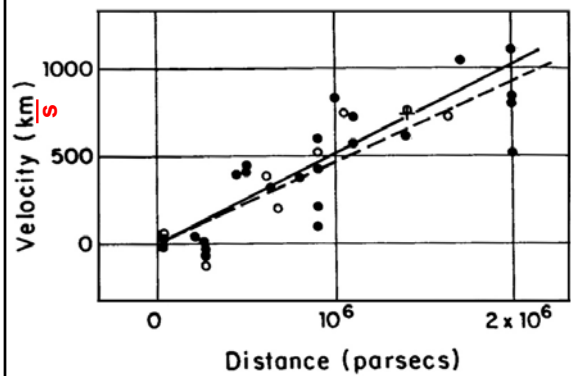




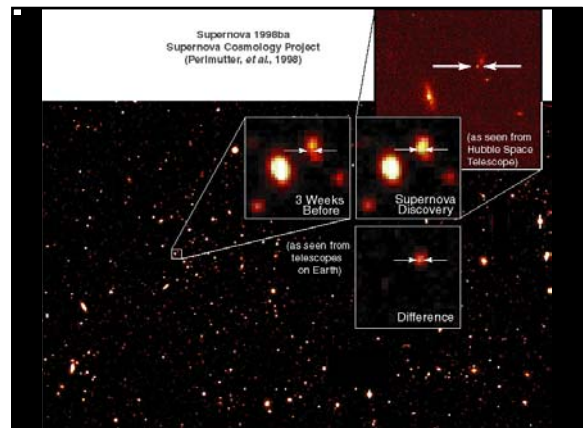
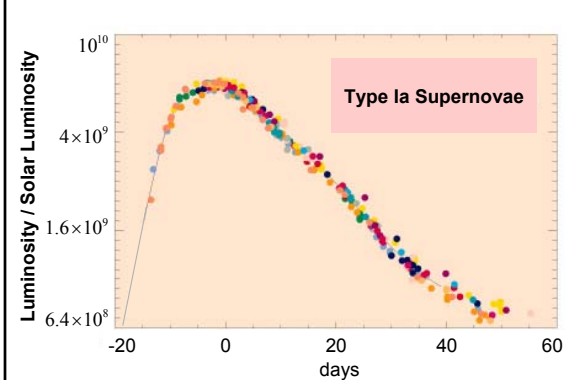
## Most of the universe is *dark*!

- Modified Newtonian dynamics
  - Planets
  - Mass disadvantaged stars  
brown red white
  - Black holes
  - The weight of space
- } gravitational microlensing

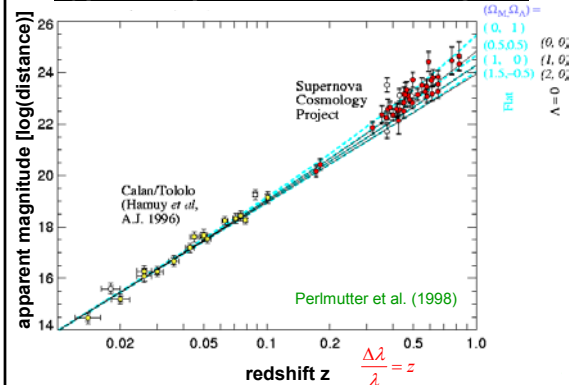
## Hubble's Discovery Paper - 1929



## Type Ia supernova are standard candles



## Type Ia supernova Hubble diagram



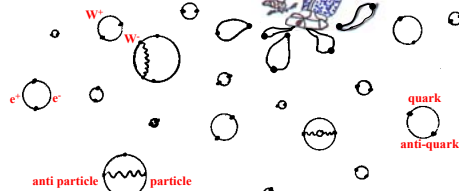
## Cosmo-illogical constant

Mass density of space:

$$\rho \approx 10^{-30} \text{ g cm}^{-3}$$

The unbearable lightness of nothing!

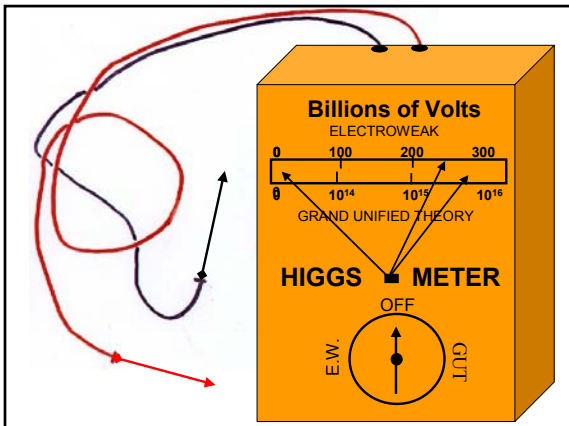
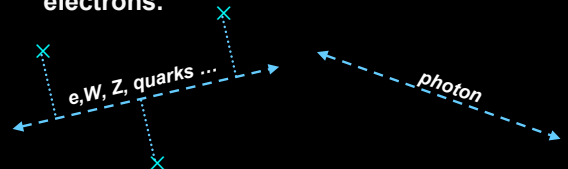
## The Vacuum of



## Quantum Uncertainty

## Nothing has energy: the Higgs potential

- The vacuum has a “Higgs potential”
- Interaction with the Higgs field potential gives mass to particles like quarks and electrons.



## Most of the universe is dark!

- Modified Newtonian dynamics
  - Planets
  - Mass disadvantaged stars  
brown red white
  - Black holes
  - The weight of space
  - Fossil remnant of the big bang
- gravitational microlensing



Absolute space,  
in its own nature,  
without relation  
to anything external,  
remains always similar  
and immovable.

Isaac Newton  
1686  
*Principia*



Space and time  
are related.

Albert Einstein  
1905

Space is dynamical  
(curved, warped, bent,  
etc.).

Albert Einstein  
1915



Space expands.

Edwin Hubble  
1929

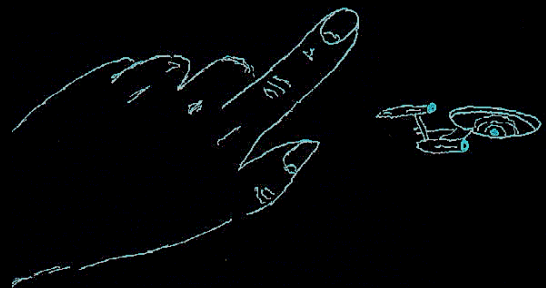


The universe  
is radiant.

Arno Penzias  
Robert Wilson  
1965



## Background radiation



$$T = 3K = -270\text{ C}$$

Every cubic inch of space is a

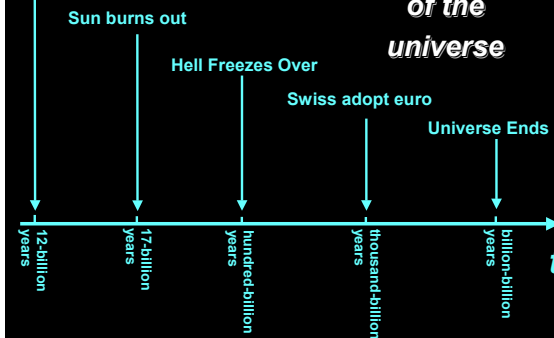
**MIRACLE!**

- Walt Whitman

- background radiation
- virtual particles
- Higgs vacuum

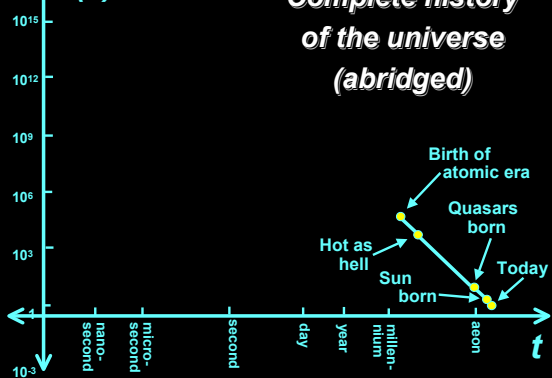
Today

**Possible future  
of the  
universe**

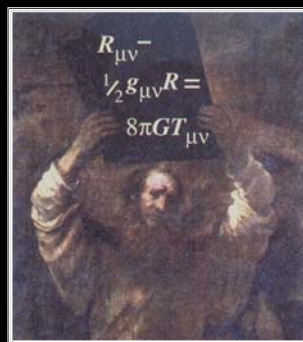


$T(^{\circ})$

**Complete history  
of the universe  
(abridged)**



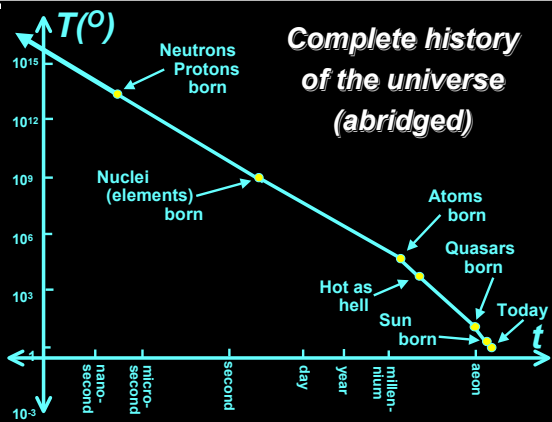
**Modern laws of Genesis**



(10 nonlinear partial differential equations)

$T(^{\circ})$

**Complete history  
of the universe  
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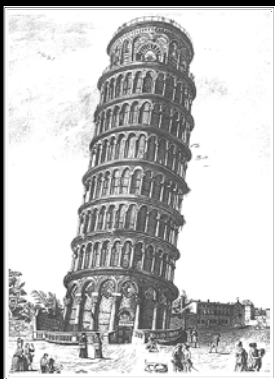


**CERN**

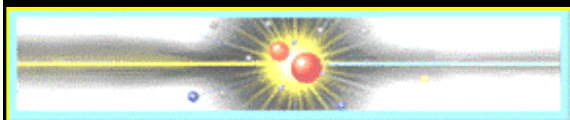


Particle Accelerator = Telescope = Time Machine

## Pisan Accelerator Laboratory



## Primordial soup



$3 \times 10^{15}$  degrees  
 $3,000,000,000,000,000^\circ$   
 $4 \times 10^{-12}$  seconds  
 $0.000\ 000\ 000\ 004$  seconds

## Primordial soup



**Caution !!!**

**CONDENSED**

50 Earth masses in matter  
 50 Earth masses in antimatter  
 + extra mountain of matter

**HOT**

64 billion years of energy output of sun

**CONTENTS**

elementary particles and antiparticles

## Primordial soup



### KNOWN INGREDIENTS:

56% QUARKS  
 16% GLUONS (STRONG FORCE)  
 9% ELECTRON-LIKE PARTICLES  
 9% W's AND Z's (WEAK FORCE)  
 5% NEUTRINOS  
 2% PHOTONS (ELECTROMAGNETIC FORCE)  
 2% GRAVITONS (GRAVITATIONAL FORCE)  
 1% HIGGS BOSONS (???)

### SECRET INGREDIENT:

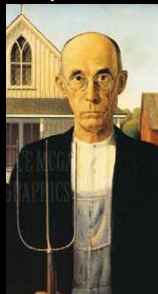
DARK MATTER

## Will Higgs be found in

USA (Fermilab)?

or

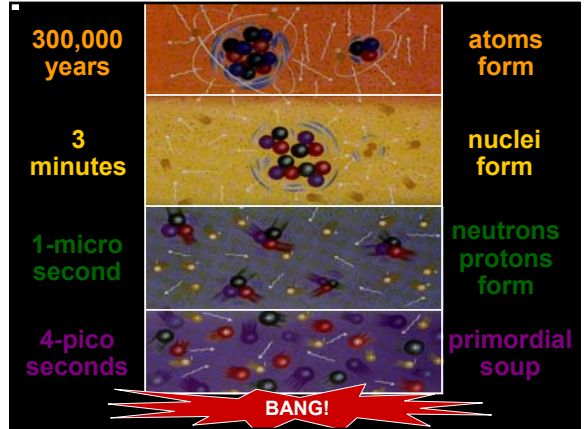
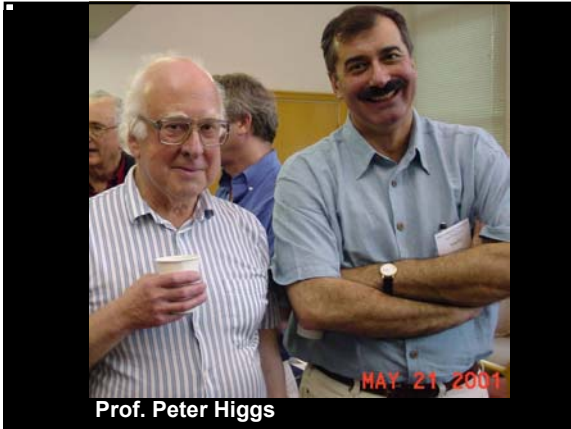
Europe (CERN)?



Mike Witherell  
 Director

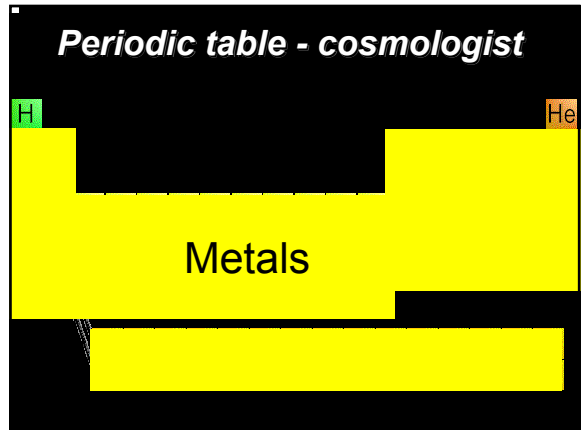


Luciano Maiani  
 Director General



# Periodic table - chemist

H																	He
Li	Be									B	C	N	O	F	Ne		
Na	Mg									Al	Si	P	S	Cl	Ar		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	



**The Universe Today:**

73%	Hydrogen	( $10^{-5}$ deuterium)
26%	Helium	( $10^{-5}$ $^3\text{He}$ )
1%	Metals	

**The Universe 3 minutes AB:**

76%	Hydrogen	( $10^{-5}$ deuterium)
24%	Helium	( $10^{-5}$ $^3\text{He}$ )
$10^{-8}\%$	Lithium	

**A wimpy idea**

- Most of the universe is *invisible*
- Dominated by the rest mass of an elementary particle (quantum)
  - present in the primordial soup
  - massive
  - neutral
  - weakly interacting
  - slow
  - stable

**WIMP**

## Neutrinos?

- Neutrinos are known to exist three active + sterile?
- Neutrinos are strongly suspected to have mass
- Massive neutrinos contribute to the mass density

Ballard Firehouse  
January 26 February 9  
\$3.00

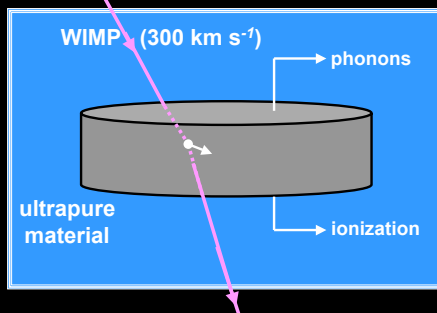
## Desperately seeking

### SUSY

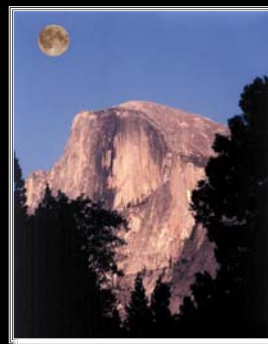
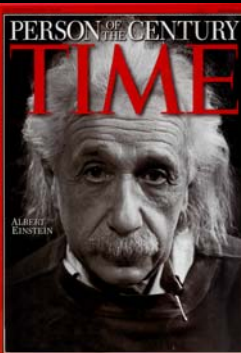
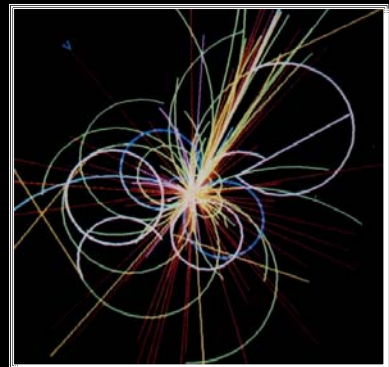
photons	↔	photinos
selectrons	↔	electrons
squarks	↔	quarks
gravitons	↔	gravitinos
wino	↔	W

Lightest superpartner *stable!*

## Direct detection in Soudan



## Make wimps in the laboratory



When one tugs at a single thing in nature, he finds it hitched to the rest of the universe.

– John Muir

